4.1 Air Surveillance

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Atmospheric releases of radioactive material from the Hanford Site to the surrounding region are a potential source of human exposure. Radioactive constituents in air are monitored at a number of locations on and around the site. The influence of Hanford emissions on the local environment was evaluated by comparing air concentrations measured at distant locations within the region to concentrations measured onsite and at the site perimeter. This section discusses sample collection techniques and analytes tested for at each location and summarizes the analytical results of the air surveillance program. A complete listing of all analytical results summarized in this section is reported separately (PNNL-13230, APP. 1). A detailed description of all radiological sampling and analytical techniques is provided in the environmental monitoring plan (DOE/RL-91-50, Rev. 2).

4.1.1 Collection of Air Samples and Analytes Tested for at Each Sample Location

Airborne radionuclide samples were collected at 44 continuously operating samplers: 23 on the Hanford Site, 11 near the site perimeter, 8 in nearby communities, and 2 in distant communities (Figure 4.1.1 and Table 4.1.1). Nine of the stations were community-operated environmental surveillance stations (discussed in Section 7.4, "Community-Operated Environmental Surveillance Program") that were managed and operated by local school teachers. Air samplers on the Hanford Site were located primarily around major operational areas to maximize the ability to detect radiological contaminants resulting from site operations. Perimeter samplers were located around the site, with emphasis on the prevailing downwind directions to the south and east of the site (discussed in Section 7.1, "Climate and Meteorology"). Continuous samplers located in Benton City, Kennewick, Mattawa, Othello, Pasco, and Richland provided data for the nearest population centers. Samplers in the distant communities of Toppenish and Yakima provided background data for communities essentially unaffected by Hanford Site operations.

Samples were collected according to a schedule established before the monitoring year (PNNL-12103). The air sampling locations and the analytes tested for at each location are given in Table 4.1.1. Airborne particles were sampled at each of these locations by continuously drawing air through a high efficiency glass-fiber filter. The samples were transported to an analytical laboratory and stored for at least 72 hours. The storage period was necessary to allow for the decay of short-lived, naturally occurring radionuclides (e.g., radon gas decay products) that would otherwise obscure detection of longer-lived radionuclides potentially present from Hanford Site emissions. The filters were then analyzed for gross beta radioactivity, and most filters were also analyzed for gross alpha radioactivity.

For most radionuclides, the amount of radioactive material collected on the filter during the 2-week period was too small to be readily measured. The sensitivity and accuracy of sample results were increased by combining biweekly samples for nearby locations (or, in some cases, a single location) into quarterly composite samples. The quarterly composite

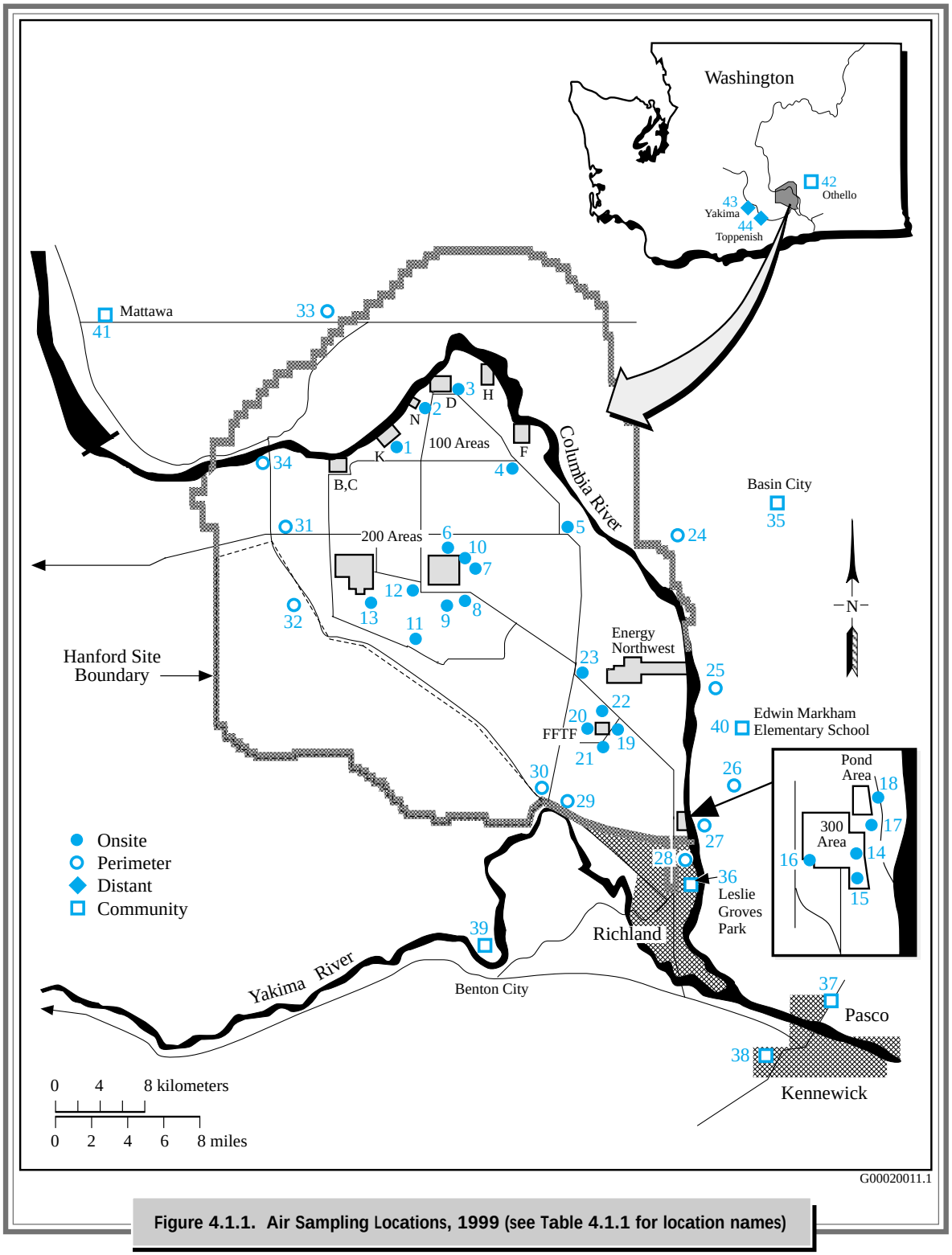

Figure 4.1.1. Air Sampling Locations, 1999 (see Table 4.1.1 for location names)

Table 4.1.1. Air Sampling Locations, Sample Composite Groups, and Analyses, 1999

Map Location[a]	Sampling Location	Analytes[b]	Composite Group	Analytes[c]
Onsite				
1	100 K Area	Alpha, Beta, ^{3}H	100 Areas	Gamma, Sr, Pu
2	100 N-1325 Crib	Alpha, Beta, ^{3}H		
3	100 D Area	Alpha, Beta		
4	100 F Met Tower	Alpha, Beta	Hanford Townsite	Gamma, Sr, Pu
5	Hanford Townsite	Alpha, Beta		
6	N of 200 E	Beta	N of 200 E	Gamma
7	E of 200 E	Alpha, Beta	200 E Area	Gamma, Sr, Pu, U
8	200 ESE	Alpha, Beta, ^{3}H, ^{129}I		
9	S of 200 E	Alpha, Beta		
10	B Pond	Alpha, Beta	B Pond	Gamma, Sr, Pu, U
11	Army Loop Camp	Alpha, Beta	200 W South East	Gamma, Sr, Pu, U
12	200 Tel. Exchange	Alpha, Beta, ^{3}H		
13	200 W SE	Alpha, Beta	200 West	Gamma, Sr, Pu, U
14	300 Water Intake	Alpha, Beta, ^{3}H	300 Area	Gamma, Sr, Pu, U
15	300 South Gate	Alpha, Beta, ^{3}H		
16	300 South West	Alpha, Beta, ^{3}H		
17	300 Trench	Alpha, Beta, ^{3}H	300 NE	Gamma, Sr, Pu, U
18	300 NE	Alpha, Beta, ^{3}H		
19	400 E	Alpha, Beta, ^{3}H	400 Area	Gamma, Sr, Pu
20	400 W	Alpha, Beta		
21	400 S	Alpha, Beta		
22	400 N	Alpha, Beta		
23	Wye Barricade	Alpha, Beta	Wye Barricade	Gamma, Sr, Pu, U
Perimeter				
24	Ringold Met Tower	Alpha, Beta, ^{3}H, ^{129}I	Ringold Met Tower	Gamma, Sr, Pu
25	W End of Fir Road	Alpha, Beta	W End of Fir Road	Gamma, Sr, Pu, U
26	Dogwood Met Tower	Alpha, Beta, ^{3}H	Dogwood Met Tower	Gamma, Sr, Pu, U
27	Byers Landing	Alpha, Beta, ^{3}H, ^{129}I	Byers Landing	Gamma, Sr, Pu, U
28	Battelle Complex	Beta	Battelle Complex	Gamma
29	Horn Rapids Substation	Alpha, Beta	Prosser Barricade	Gamma, Sr, Pu, U
30	Prosser Barricade	^{3}H		
31	Yakima Barricade	Alpha, Beta	Yakima Barricade	Gamma, Sr, Pu
32	Rattlesnake Springs	Alpha, Beta		
33	Wahluke Slope	Alpha, Beta, ^{3}H	Wahluke Slope	Gamma, Sr, Pu
34	S End Vernita Bridge	Alpha, Beta		

Table 4.1.1. (contd)

Map Location[a]	Sampling Location	Analytes[b]	Composite Group	Analytes[c]
Nearby Communities				
35	Basin City School[d]	Alpha, Beta, ^{3}H	Basin City School	Gamma, Sr, Pu, U
36	Leslie Groves-Rchlnd[d]	Alpha, Beta, ^{3}H	Leslie Groves-Rchlnd	Gamma, Sr, Pu, U
37	Pasco[d]	Beta	Tri-Cities	Gamma, Sr, Pu
38	Kennewick[d]	Alpha, Beta		
39	Benton City[d]	Beta	Benton City	Gamma
40	Edwin Markham School[d]	Alpha, Beta, ^{3}H	Edwin Markham School	Gamma, Sr, Pu, U
41	Mattawa[d]	Beta	Mattawa	Gamma
42	Othello[d]	Beta	Othello	Gamma
Distant Communities				
43	Yakima	Alpha, Beta, ^{3}H, ^{129}I	Yakima	Gamma, Sr, Pu, U
44	Toppenish[d]	Alpha, Beta, ^{3}H	Toppenish	Gamma, Sr, Pu, U

(a) See Figure 4.1.1.
(b) Alpha (gross) and beta (gross) samples are collected and analyzed every 2 weeks, ^{3}H samples are collected and analyzed every 4 weeks, and ^{129}I samples are collected every 4 weeks, combined into a quarterly composite sample and analyzed for each location.
(c) Gamma scans, strontium-90, isotopic plutonium (^{238}Pu, $^{239/240}Pu$), and isotopic uranium (^{234}U, ^{235}U, ^{238}U) analyses are performed on quarterly composite samples.
(d) A community-operated environmental surveillance station.

samples were analyzed for specific gamma-emitting radionuclides (Appendix E), strontium-90, and plutonium isotopes, with selected composites also analyzed for uranium isotopes.

Samples were collected for iodine-129 at four locations by drawing air through a cartridge containing chemically treated, special, low-background petroleum-charcoal positioned downstream of a particle filter. Samples were collected monthly and combined to form quarterly composite samples for each location.

Atmospheric water vapor was collected for tritium analysis at 20 locations by continuously passing air through cartridges containing silica gel, which were exchanged every 4 weeks. The collection efficiency of the silica gel adsorbent is discussed in Patton et al. (1997). The collected water was distilled from the silica gel and analyzed for its tritium content.

Some air samples were collected at nine community-operated environmental surveillance stations (see Section 7.4, "Community-Operated Environmental Surveillance Program"). These samples were collected by local teachers as part of an ongoing DOE-sponsored program to promote public awareness of Hanford Site environmental monitoring programs. The samples were submitted to the analytical laboratory and treated the same as all other submitted samples.

4.1.2 Radiological Results for Air Samples

Radiological air sampling results for onsite, site perimeter, nearby communities, and distant communities for gross alpha, gross beta, and specific radionuclides are summarized in Table 4.1.2.

A detectable value is defined in this section as a value reported above the minimum detectable activity or above the 2-sigma total propagated analytical uncertainty. A gamma-emitting radionuclide is detectable if the radionuclide library of the software determines an isotope activity above the minimum detectable activity of a sample. The nominal detection limit is defined as the average 2-sigma total propagated analytical uncertainty of the population of reported values.

The average gross alpha radioactivity concentrations at the site perimeter appeared to be slightly elevated compared to the levels measured at distant stations (see Table 4.1.2); however, the difference was not statistically significant (log transformed, two-tailed t-test, 5% significance level), indicating that the observed levels were predominantly a result of natural sources and worldwide radioactive fallout. The gross alpha average concentration values were similar to values reported for 1994 through 1999 (see Figure 4.1.2). The highest onsite gross alpha concentration was at the Wye Barricade sampling location (23 on Figure 4.1.1).

Tritium concentrations measured in 1999 (excluding 300 Area samples) were similar to values reported for 1995 through 1998 (see Table 4.1.2 and Figure 4.1.3) and did not show the highly elevated concentrations and widely variable results reported for 1991 through 1994 (Section 4.1 in PNL-11139). For 1999, ~77% of the samples analyzed for tritium had results reported above the detection limit (the method is capable of detecting concentrations of no less than 3 pCi/m^3). Sample results above the detection limit were consistently determined for the 300 Area samples. Tritium releases in the 300 Area are associated with research and development activities (see Table 3.1.1). These research and development activities are expected to continue for the next year; therefore, higher tritium concentrations are expected for the 300 Area samples in 2000 as well. Figure 4.1.3 shows the slightly elevated 300 Area average tritium concentration with respect to other onsite average tritium concentrations, as well as perimeter and distant locations.

The annual average tritium concentration measured at the site perimeter (2.3 ± 0.8 pCi/m^3) appeared to be slightly higher than the annual average value at the distant locations (1.9 ± 0.76 pCi/m^3); however, the difference was not statistically significant (log transformed, two-tailed t-test, 5% significance level). The annual average tritium concentrations measured at the site perimeter in 1999 was less than 0.003% of the 100,000-pCi/m^3 DOE derived concentration guide (DOE Order 5400.5).

Gross beta concentrations in air for 1999 (Figure 4.1.4) peaked during the winter, repeating a pattern of natural annual radioactivity fluctuations (Eisenbud 1987). The average gross beta concentration was slightly higher at the site perimeter than the annual average concentration value at the distant location. The values were slightly lower than values reported for 1994 through 1999 (see Table 4.1.2).

For samples analyzed for strontium-90 in 1999 (Figure 4.1.5), 21 of the 92 samples were above the detection limit (see Table 4.1.2). The perimeter average appears to be elevated with respect to the distant concentrations; however, the difference was not statistically significant (log transformed, two-tailed t-test, 5% significance level). The highest level (210 ± 190 aCi/m^3) was determined for the Leslie Groves, Richland composite sample (location 36 on Figure 4.1.1), which is 0.003% of the 9,000,000-aCi/m^3 derived concentration guide.

Iodine-129 analyses were performed on samples collected downwind of the Plutonium-Uranium

Table 4.1.2. Airborne Radionuclide Concentrations in the Hanford Environs, 1999 Compared to Previous Years

Radionuclide	Location Group[a]	1999 No. of Samples	1999 No. of Detections[b]	1999 Maximum[c]	1999 Average[d]	1995-1998 No. of Samples	1995-1998 No. of Detections[b]	1995-1998 Maximum[c]	1995-1998 Average[d]	Derived Concentration Guide[e]
				pCi/m³	pCi/m³			pCi/m³	pCi/m³	pCi/m³
Tritium	300 Area	70	68	11 ± 1.5	4.2 ± 0.51	199	81	25 ± 3.0	1.7 ± 0.34	100,000
	Onsite	65	47	4.8 ± 1.0	2.1 ± 0.26	254	88	24 ± 20	1.2 ± 0.24	
	Perimeter	65	43	24 ± 2.3	2.3 ± 0.80	251	57	12 ± 22	1.0 ± 0.20	
	Nearby communities	36	30	13 ± 1.2	2.9 ± 0.88	158	34	16 ± 15	1.3 ± 0.35	
	Distant communities	24	14	7.9 ± 1.1	1.9 ± 0.76	117	16	5.2 ± 5.0	0.69 ± 0.16	
		1999				1994-1998				
				pCi/m³	pCi/m³			pCi/m³	pCi/m³	
Gross beta	Onsite	589	589	0.041 ± 0.0069	0.013 ± 0.00048	2,505	2,503	0.070 ± 0.0070	0.018 ± 0.00043	No standard
	Perimeter	253	252	0.047 ± 0.0077	0.013 ± 0.00079	998	995	0.098 ± 0.010	0.017 ± 0.00061	
	Nearby communities	209	209	0.033 ± 0.0056	0.013 ± 0.00083	964	964	0.062 ± 0.0062	0.017 ± 0.00057	
	Distant communities	57	56	0.028 ± 0.0043	0.011 ± 0.0013	290	290	0.095 ± 0.0099	0.015 ± 0.0012	
				aCi/m³	aCi/m³			aCi/m³	aCi/m³	aCi/m³
Gross alpha	Onsite	562	452	2,900 ± 1,200	670 ± 35	2,280	1,729	5,500 ± 1,300	540 ± 15	No standard
	Perimeter	232	198	2,600 ± 1,200	700 ± 55	902	725	2,200 ± 600	560 ± 22	
	Nearby communities	113	92	2,100 ± 760	670 ± 76	532	426	1,900 ± 730	540 ± 25	
	Distant communities	57	46	1,400 ± 730	620 ± 89	290[f]	202	2,300 ± 100	440 ± 40	
Strontium-90	Onsite	40	13	160 ± 59	30 ± 15	52	19	300 ± 96	35 ± 20	9,000,000
	Perimeter	28	6	110 ± 72	25 ± 14	35	8	390 ± 79	16 ± 24	
	Nearby communities	16	1	210 ± 190	35 ± 34	20	5	69 ± 32	8.6 ± 11	
	Distant communities	8	1	79 ± 37	13 ± 32	11	1	78 ± 27	15 ± 19	
Iodine-129	Onsite	4	4	27 ± 1.3	22 ± 4.3	20	20	50 ± 12	32 ± 5.1	70,000,000
	Perimeter	8	8	1.4 ± 0.84	0.82 ± 0.47	40	40	2.3 ± 0.28	1.0 ± 0.17	
	Distant communities	4	4	0.081 ± 0.0055	0.040 ± 0.028	21	21	0.10 ± 0.010	0.055 ± 0.010	
Plutonium-238	Onsite	40	2	2.9 ± 5.8	-0.04 ± 0.19	52	3	2.9 ± 0.94	-0.08 ± 0.15	30,000
	Perimeter	28	1	1.9 ± 1.4	-0.055 ± 0.20	35	0	3.1 ± 4.1	-0.014 ± 0.23	
	Nearby communities	16	0	0.73 ± 1.3	-0.14 ± 0.28	20	1	0.76 ± 3.3	-0.0041 ± 0.17	
	Distant communities	8	0	0.17 ± 1.2	-0.30 ± 0.20	11	0	0.86 ± 3.5	0.12 ± 0.23	

Table 4.1.2. (contd)

Radionuclide	Location Group[a]	1999 No. of Samples	1999 No. of Detections[b]	1999 Maximum[c]	1999 Average[d]	1994-1998 No. of Samples	1994-1998 No. of Detections[b]	1994-1998 Maximum[c]	1994-1998 Average[d]	Derived Concentration Guide[e]
				aCi/m³	aCi/m³			aCi/m³	aCi/m³	aCi/m³
Plutonium-239/240	Onsite	40	12	10 ± 4.5	1.0 ± 0.59	52	23	12 ± 2.5	1.2 ± 0.60	20,000
	Perimeter	28	4	4.1 ± 3.3	0.63 ± 0.34	35	10	1.5 ± 0.8	0.34 ± 0.13	
	Nearby communities	16	2	1.3 ± 1.6	0.46 ± 0.29	20	5	1.3 ± 3.1	0.17 ± 0.21	
	Distant communities	8	1	3.2 ± 2.9	0.94 ± 0.81	11	2	1.2 ± 1.2	0.18 ± 0.26	
Uranium-234	Onsite	32	28	85 ± 21	27 ± 7.6	44	43	140 ± 210	25 ± 6.7	90,000
	Perimeter	16	16	66 ± 21	34 ± 8.4	20	20	45 ± 8.9	27 ± 4.7	
	Nearby communities	12	12	54 ± 17	33 ± 6.9	15	15	33 ± 15	24 ± 3.0	
	Distant communities	8	7	41 ± 15	23 ± 6.9	11	11	27 ± 8.9	17 ± 2.9	
Uranium-235	Onsite	32	2	3.7 ± 2.7	0.63 ± 0.46	44	12	51 ± 130	2.0 ± 2.3	100,000
	Perimeter	16	0	6.0 ± 6.0	0.86 ± 1.0	20	10	3.4 ± 2.1	1.3 ± 0.45	
	Nearby communities	12	1	6.2 ± 5.6	0.85 ± 1.3	15	6	4.3 ± 4.8	1.2 ± 0.47	
	Distant communities	8	0	6.2 ± 6.3	0.57 ± 1.7	11	0	3.3 ± 4.0	0.73 ± 0.68	
Uranium-238	Onsite	32	30	92 ± 27	25 ± 7.2	44	43	58 ± 14	19 ± 3.8	100,000
	Perimeter	16	16	59 ± 20	29 ± 7.7	20	20	43 ± 8.6	26 ± 4.5	
	Nearby communities	12	11	56 ± 18	28 ± 8.3	15	15	35 ± 14	24 ± 3.7	
	Distant communities	8	8	33 ± 15	22 ± 0.54	11	10	23 ± 8.1	16 ± 3.0	
Cobalt-60	Onsite	50	0	430 ± 690	64 ± 53	204	20	880 ± 490	66 ± 38	80,000,000
	Perimeter	32	0	760 ± 630	120 ± 110	144	9	1,000 ± 530	23 ± 52	
	Nearby communities	29	0	1,000 ± 960	87 ± 110	93	4	800 ± 560	1.2 ± 65	
	Distant communities	9	0	230 ± 690	-52 ± 130	45	3	680 ± 440	170 ± 76	
Cesium-137	Onsite	50	0	530 ± 730	52 ± 52	204	14	710 ± 530	15 ± 40	400,000,000
	Perimeter	32	0	240 ± 630	-62 ± 83	144	5	660 ± 620	2.7 ± 43	
	Nearby communities	29	0	240 ± 600	-76 ± 93	93	4	860 ± 580	48 ± 50	
	Distant communities	9	0	390 ± 580	13 ± 220	45	1	390 ± 290	30 ± 66	

(a) Location groups are identified in Table 4.1.1.
(b) Detection is defined as a value reported above the minimum detectable activity or above the 2-sigma total propagated analytical uncertainty. Gamma-emitting radionuclide, cobalt-60 and cesium-137, detections are above the minimum detectable activity.
(c) Maximum single sample result ± total propagated analytical uncertainty at 2-sigma. Negative concentration values are explained in the section "Helpful Information."
(d) Average of all samples ±2 times the standard error of the mean.
(e) DOE derived concentration guide (DOE Order 5400.5; see Appendix C, Table C.5).
(f) Two results from the distant communities were excluded as anomalous values through the use of a Q-test (26,300 ± 3,400 aCi/m³ at Sunnyside and 8,000 ± 1,000 aCi/m³ at Yakima [Skoog and West 1980]).

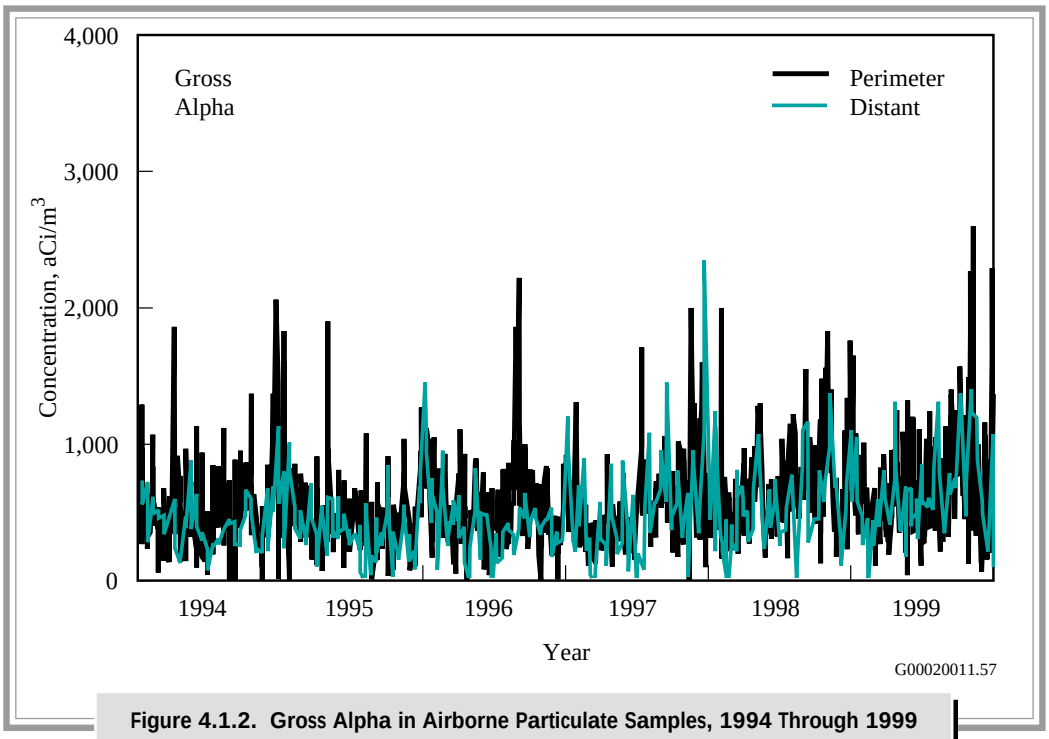

Figure 4.1.2. Gross Alpha in Airborne Particulate Samples, 1994 Through 1999

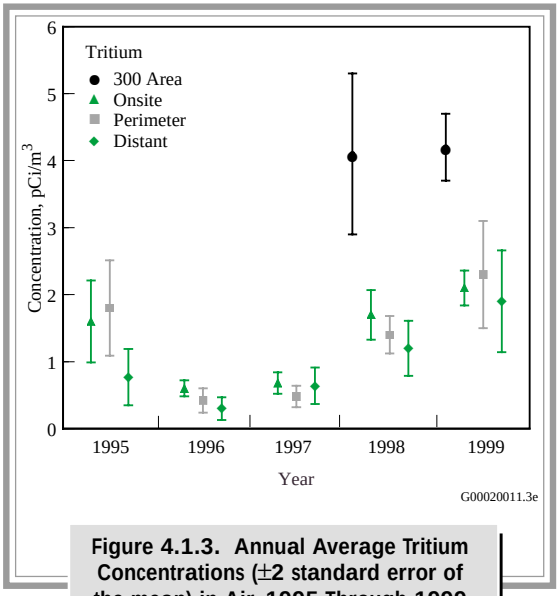

Figure 4.1.3. Annual Average Tritium Concentrations (±2 standard error of the mean) in Air, 1995 Through 1999

Extraction Plant, at two downwind perimeter locations, and at a distant location (Yakima) in 1999 (see Figure 4.1.1). Onsite concentrations in 1999 were elevated compared to those measured at the site perimeter, and perimeter levels were higher than those measured at Yakima, the distant location (Figure 4.1.6 and see Table 4.1.2). Iodine-129 concentration differences between these locations were statistically significant (log transformed, two-tailed t-test, 5% significance level) and indicated a Hanford source. Onsite and perimeter air concentrations have remained at their respective levels from 1994 through 1999 (see Figure 4.1.6). Onsite air concentrations of iodine-129 were influenced by minor emissions (0.00019 curie; see Table 3.1.1) from the Plutonium-Uranium Extraction Plant and possible releases from waste storage tanks and cribs. The annual average iodine-129 concentration at the downwind perimeter in 1999 (0.82 ± 0.47 aCi/m^3) was less than 0.000001% of the 70,000,000-aCi/m^3 derived concentration guide.

Plutonium-238 was detected in two onsite samples and one perimeter sample for 1999 (nominal

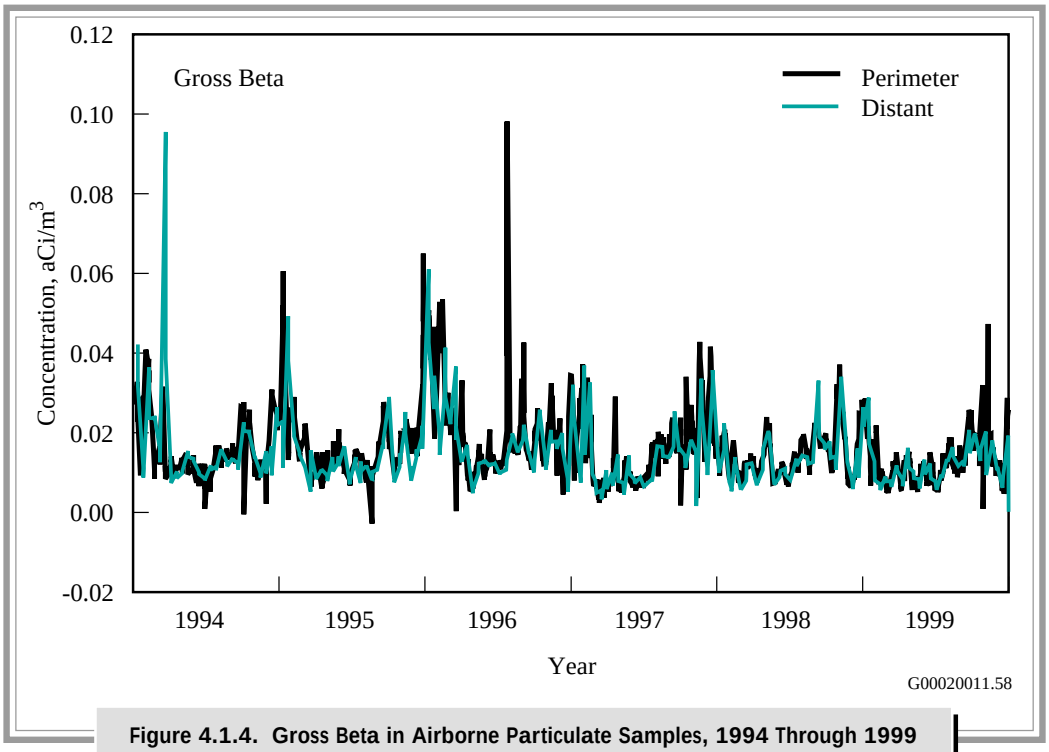

Figure 4.1.4. Gross Beta in Airborne Particulate Samples, 1994 Through 1999

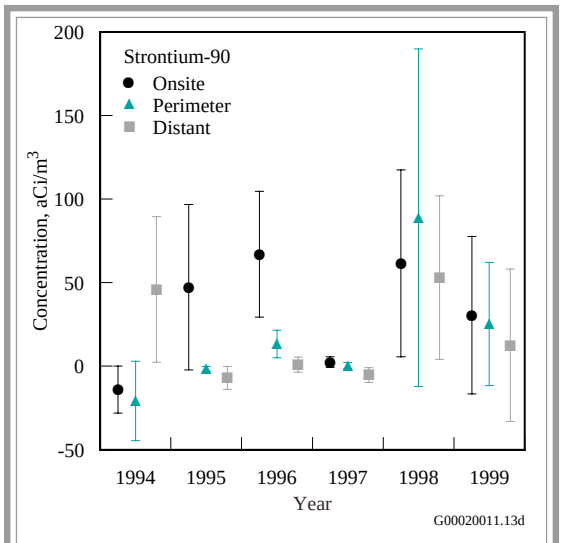

Figure 4.1.5. Annual Average Strontium-90 Concentrations (±2 standard error of the mean) in Air, 1994 Through 1999

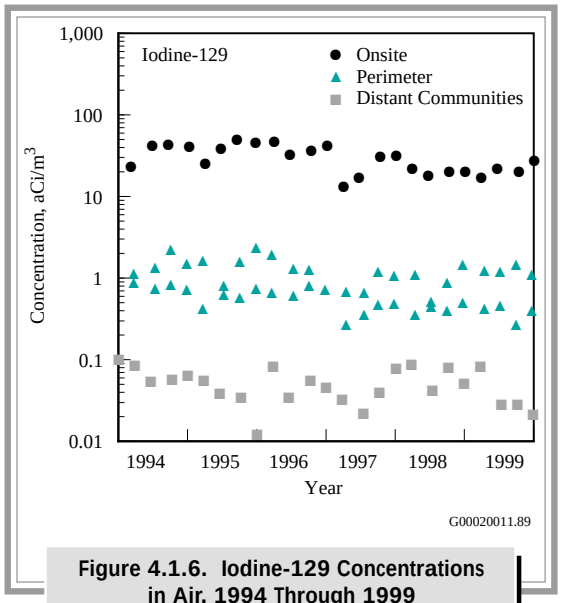

Figure 4.1.6. Iodine-129 Concentrations in Air, 1994 Through 1999

detection limit of 0.98 aCi/m^3). The annual average air concentration of plutonium-238 for all samples was less than zero (i.e., not detected). The highest concentration (2.9 ± 5.8 aCi/m^3) was determined for the B Pond sample (location 10 on Figure 4.1.1 and Table 4.1.1), which is 0.01% of the 30,000-aCi/m^3 derived concentration guide.

The average plutonium-239/240 concentrations detected in onsite and offsite air samples are given in Table 4.1.2 and Figure 4.1.7. The annual average air concentration of plutonium-239/240 at the site perimeter was 0.63 ± 0.34 aCi/m^3, which is less than 0.003% of the 20,000-aCi/m^3 derived concentration guide. The annual average air concentration appeared to be slightly lower for the site perimeter locations (0.63 ± 0.34 aCi/m3) than the distant locations (0.94 ± 0.81 aCi/m3); however, the difference was not statistically significant (log transformed, two-tailed t-test, 5% significance level). The maximum Hanford Site plutonium-239/240 air concentration (10.0 ± 4.5 aCi/m^3) was observed for the Wye Barricade composite sample (location 23 on Figure 4.1.1). This represents less than 0.05% of the 20,000-aCi/m^3 derived concentration guide.

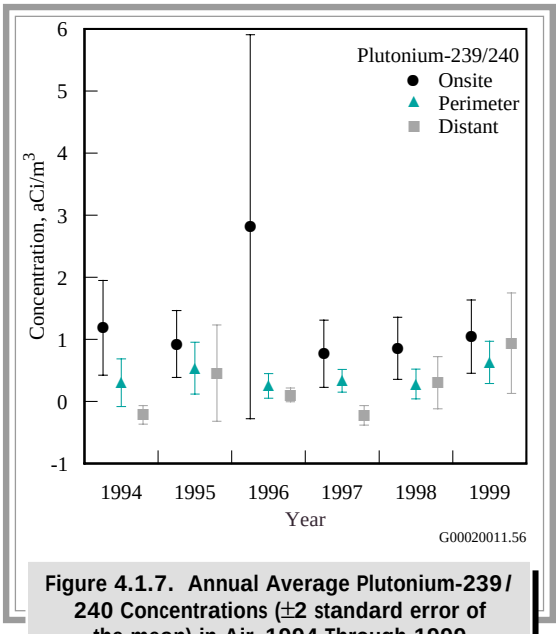

Figure 4.1.7. Annual Average Plutonium-239/240 Concentrations (±2 standard error of the mean) in Air, 1994 Through 1999

Average isotopic uranium concentrations (uranium-234, -235, and -238) in airborne particulate matter in 1999 were similar on the site, at the site perimeter, and at distant communities (see Table 4.1.2). The average isotopic uranium concentrations were also similar to the past 2 years' average concentrations (Figure 4.1.8). The 1999 annual average uranium-238 concentration for the site perimeter was 29 ± 7.7 aCi/m^3, which is 0.03% of the 100,000-aCi/m^3 derived concentration guide.

Samples were analyzed quarterly, and at some locations annually, by gamma spectroscopy. Naturally occurring beryllium-7 and potassium-40 were routinely identified. The potential Hanford-origin gamma-emitting radionuclides of cobalt-60 and cesium-137 associated with airborne particulate matter were monitored by gamma spectroscopy. Of the 120 samples analyzed by gamma spectroscopy, none of the samples had activities above the minimum detectable level for the sample for that isotope. The cobalt-60 and cesium-137 results for 1999 samples are included in Table 4.1.2. Even the maximum estimated individual measurements for these radionuclides (1,000 ± 960 and 530 ± 730 aCi/m^3, respectively) were less than 0.002% of their derived concentration guides.

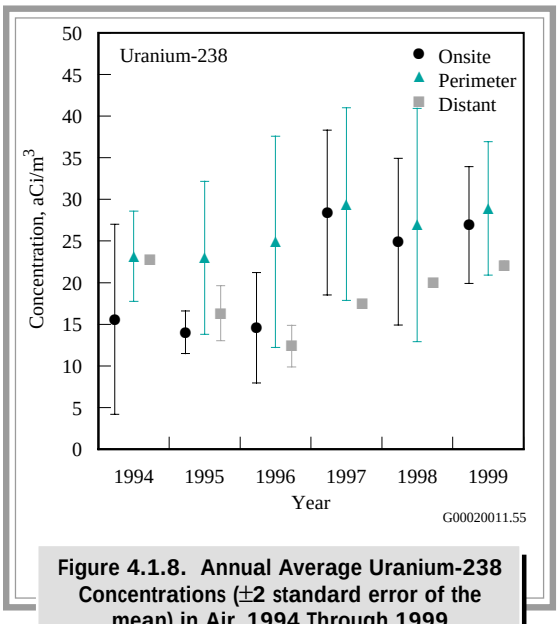

Figure 4.1.8. Annual Average Uranium-238 Concentrations (±2 standard error of the mean) in Air, 1994 Through 1999